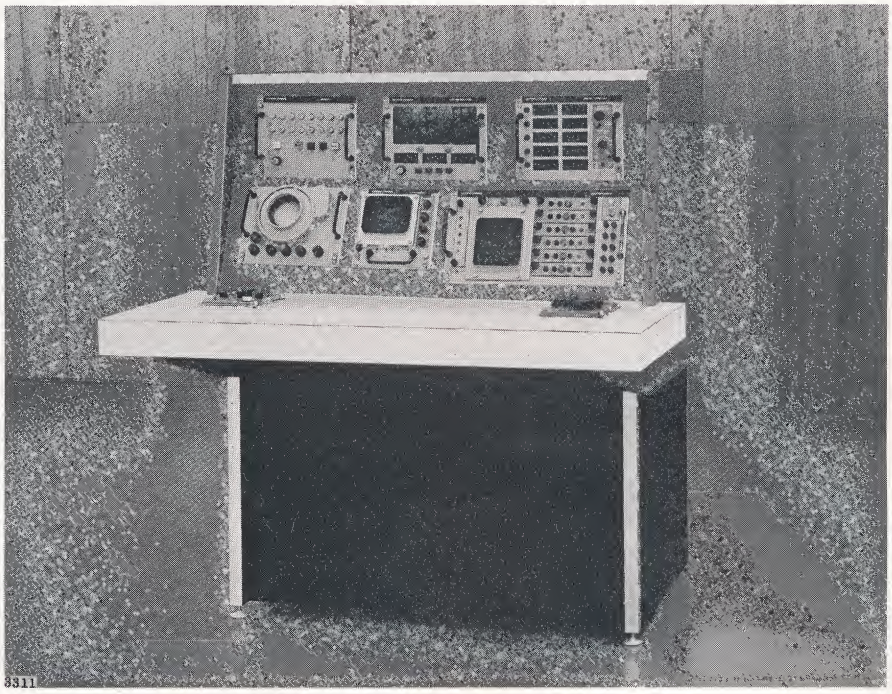
WATKINS ■ JOHNSON COMPANY TECHNICAL BULLETIN

Vol. 8, No. 5; February, 1966

WJ-1007
MICROWAVE COLLECTION SYSTEM

- 1-18 GHz FREQUENCY RANGE.
- MODULAR COMPONENTS FOR FERRET, ELINT & RFI APPLICATIONS.
- NO MECHANICAL TUNING—ELECTRICALLY-TRACKED PRESELECTORS & OSCILLATORS.
- CONTINUOUS COVERAGE—AUTOMATICALLY SWITCHED FREQUENCY BANDS.
- DIGITAL TUNING AND DIRECT DIGITAL READOUT.
- AIRBORNE, SHIPBOARD, MOBILE VAN, OR FIXED STATION APPLICATION.



The WJ-1007 is a microwave electromagnetic surveillance system capable of receiving, detecting and analyzing state-of-the-art electromagnetic emissions in the frequency range of 1 to 18 GHz. Although the Microwave Collection System has been initially designed for airborne application, its modular construction makes it equally suitable for use in mobile vans or as fixed station equipment. The entire system, less antenna drive units and cables occupies a volume of approximately 18 ft.³ and weighs less than 850 lbs. Solid-state circuitry is used throughout except for low-noise traveling-wave tubes, display tubes and Ku band backward-wave oscillator.

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Basically, four signal functions are supplied by the WJ-1007: acquisition, control, analysis, and recording. Each function is represented by one or more modules. The system is capable of detecting and categorizing the parameters of currently used types of electromagnetic emission. Sufficient system flexibility and automatic digital computer functions are included to insure rapid signal acquisition and analysis. Data resulting from signal analysis is printed out and transmitted directly without manual or visual translation by the operator.

The WJ-1007 covers the entire 1 to 18 GHz frequency spectrum with a continuous sweep. To give maximum signal-to-noise ratio throughout the spectrum and to provide optimum system flexibility, the spectrum is divided into five standard microwave bands. There is no mechanical tuning involved within these bands, nor mechanical switching required between bands. Fully-electronic tuning is a result of incorporation of YIG filters as preselectors and in oscillators. A memory module is included to permit programing the spectrum such that certain frequencies may be recalled, or bands of frequencies automatically locked-out.

Other features of the WJ-1007 Microwave Collection System include digital frequency tuning (manual and automatic); direct digital readout of frequency, pulse repetition period, and pulse length; panoramic display of the entire frequency spectrum (in five bands) with integral photographic capability; spectrum analysis with 100 kc/s resolution; bandwidth, IF mode, and signal type selection; and antenna control for direction finding with separate display unit.

SIGNAL ACQUISITION

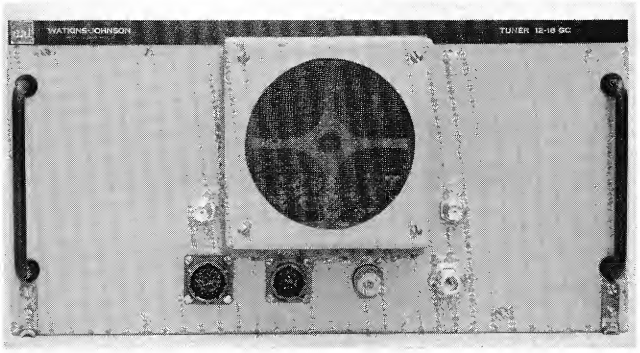
Five RF Tuning Units process incoming signals and provide the first conversion to a nominal 250 MHz IF output (190–310 MHz). One tuning unit is used for each of the microwave bands (L, S, C, X and K_u). The tuning units contain a YIG preselector and postselector to provide image and spurious response rejection for the first IF conversion. A traveling-wave-tube amplifier is provided between the YIG filters to insure adequate low-noise amplification. A local oscillator is provided to tune each band in 100 MHz increments.

Diplexers

The current system is designed for use with three separate antennas and includes two Diplexer Units which split the incoming RF energy. Antennas for 1–4 GHz and 8–18 GHz have their output fed to a diplexer, while the output from the third antenna (4–8 GHz) is fed directly to a RF Tuning Unit. The 1 to 4 GHz diplexer divides the RF energy into two bands of 1–2 GHz and 2–4 GHz; the outputs from each diplexer being fed to individual RF Tuning Units with attenuation control. The 8–18 GHz energy is similarly split (8–12 GHz and 12–18 GHz), except that the output is fed directly to the remaining two RF Tuning Units without attenuation control.

RF Tuning Units

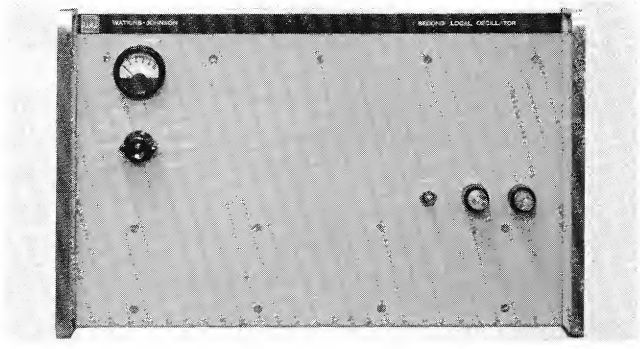
The passband of the YIG (yttrium-iron-garnet) filters is controlled electromagnetically. The RF energy for each band is fed through separate YIG filters and traveling-wave-tube amplifiers. These amplifiers provide the receiver with an extremely low noise figure. The outputs from the amplifiers are then coupled to another bank of YIG filters to provide an additional stage of postselection prior to being fed to the first mixer-preamplifiers.

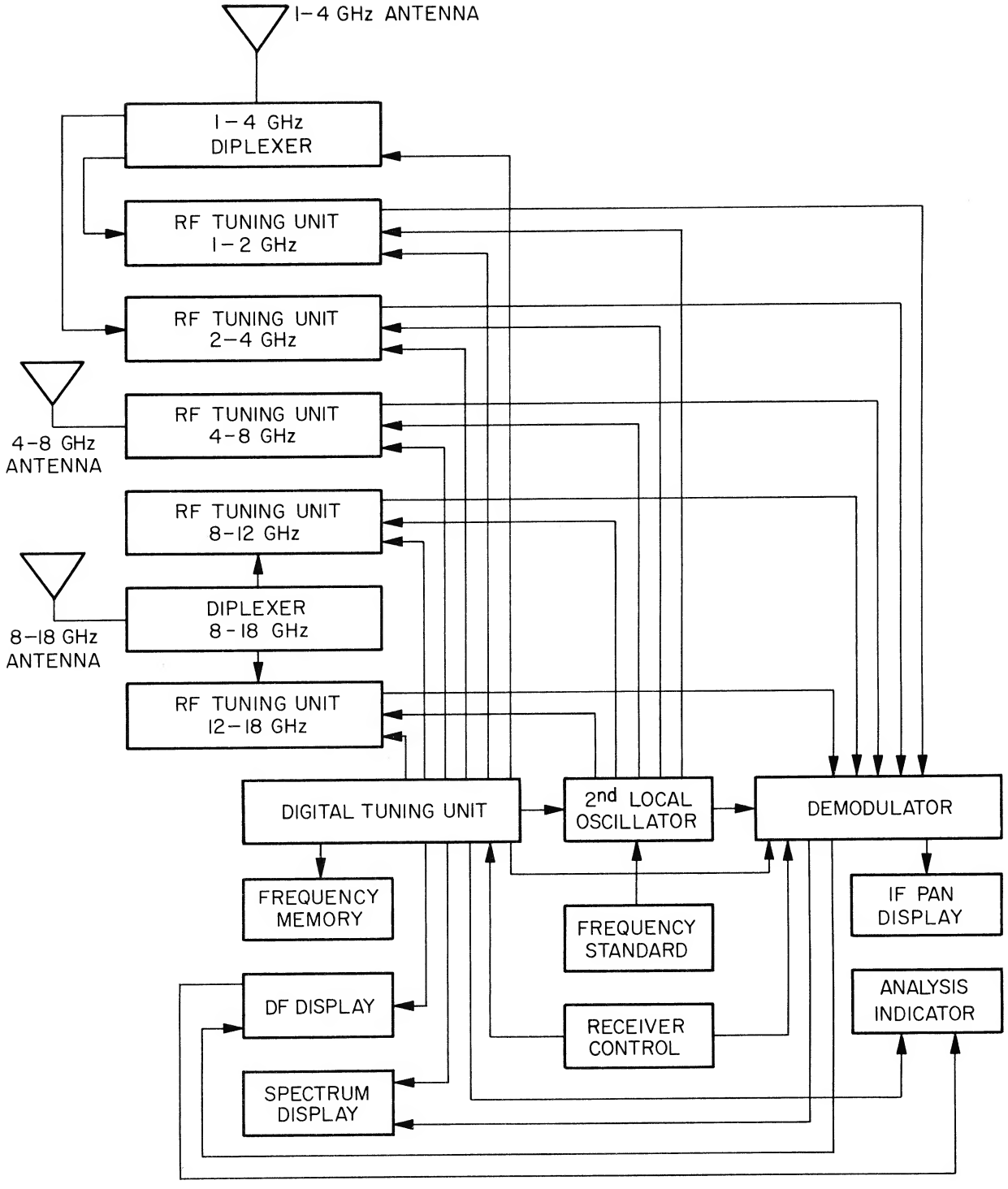


The mixer-preamplifiers use balanced mixers and solid-state preamplifiers providing the 250 MHz IF output frequency at a power gain of 25 dB. Their output is fed to an IF commutator switch located in the Demodulator Unit. Oscillator injection is supplied by YIG-tuned harmonic generators which are driven by the Local Oscillator Synthesizer Unit. C and X band harmonic generators are each followed by a traveling-wave-tube amplifier to increase the output level, and a BWO is used for Ku band. L and S band harmonic generators are coupled directly to the mixer stages without additional amplification.

Local Oscillator Synthesizer Unit

The Local Oscillator Synthesizer Unit produces the basic oscillator frequencies for both first and



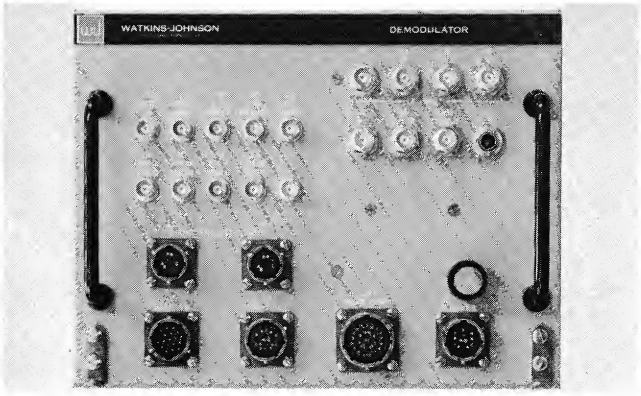


WJ-1007 Microwave Collection System, Functional Diagram

second conversion. The output fed to the harmonic generators in the RF Tuning Units (first conversion) is fixed at 100 MHz. The second output is fed to the second conversion circuitry in the Demodulator Unit. This output is stepped from 260 to 360 MHz in 100 kc/s increments. Stepping is controlled by the Digital Tuning and Receiver Control Units.

Demodulator Unit

The Demodulator Unit accepts the 250 MHz IF output from the appropriate RF Tuning Unit. The proper tuning unit is selected by a diode bandswitch and fed to an IF attenuator. When mixed with the output from the local oscillator the resultant IF frequency becomes 60 MHz. The 60 MHz amplifiers are all at least 25 MHz wide and the 20, 5 and 1 MHz bandwidths are determined by passive plug-in type filters in the amplifier chain. Selection of the desired filter bandwidth is accomplished from the Receiver Control Unit. These filters may be replaced with other units providing a different selection of bandwidths for special applications.

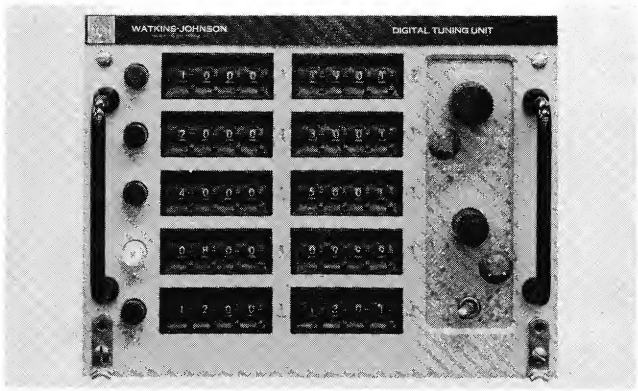


The 60MHz information is split and fed to the IF Pan Display Unit mixer, the AM detectors and the FM detector. The AM detectors consist of separate linear and logarithmic IF amplifiers and detectors which feed the IF Pan Display Unit and Spectrum Display Unit. Selection of either linear or logarithmic amplifiers, and AM and FM mode of reception is controlled by the Receiver Control Unit. The FM detector consists of a limiter and discriminator which is followed by a variable gain video amplifier. This FM output is fed to the display circuits and is available as an external output.

SIGNAL CONTROL

Digital Tuning Unit

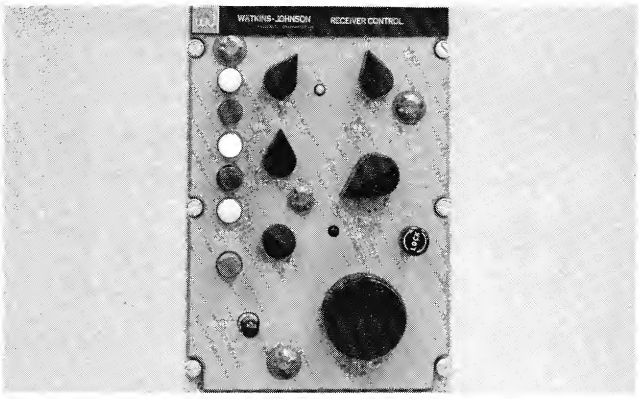
The Digital Tuning Unit controls selection of scanning of the 1 to 18 GHz spectrum. The unit has ten sets of thumbwheel switches to allow presetting start-sweep and stop-sweep points in all of the five microwave bands. The switches control operation of a sweep counter which consists of six decade counters that define tuning increments between 1 and 18 GHz in 100 kc/s increments. A matrix connected to the 1 and 10 GHz decade counters performs bandswitching. The Digital Tuning Unit also has front panel controls for adjusting sweep speed and sweep threshold, plus a switch for selecting sector or continuous sweep mode of operation. When set in the continuous sweep mode, the sweep counter scans the entire 1 to 18 GHz spectrum without regard to settings of the thumbwheel switches.



Sweeping speed is continuously adjustable from 0.3 to 300 GHz/sec. Signal lock-on is controlled by the threshold adjustment which determines the minimum SNR necessary to de-activate automatic sweeping action.

Receiver Control Unit

The Receiver Control Unit operates in conjunction with the Digital Tuning Unit to provide the dynamic tuning control system for the receiver. The Receiver Control Unit is fundamentally a remote control head for the RF Tuning Units. It is packaged to fit a standard aircraft dzus bay opening and contains additional controls (not found on the Digital Tuning Unit) necessary to operate the receiver system.



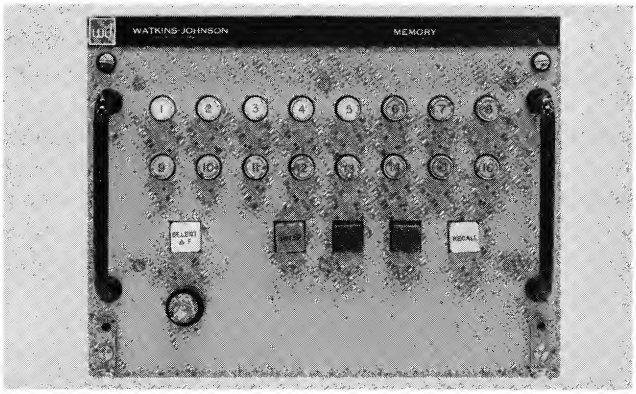
The Receiver Control Unit is used to control received mode, IF bandwidth and mode, signal attenuation, manual sweep start-stop, manual tuning, and to indicate the band being swept. Push-switch type

indicators are used for displaying which band is being swept. The switch portion of these indicators may be used to stop the sweep at any point within a band, or may be operated to stop the sweeping action at the lower limit of any desired band.

For operator convenience, a single manual tune control and a three-speed fast tune lever (which operates in two directions) are provided. The manual tuning control tunes 10 MHz per turn of the dial. The fast tune lever is a spring-return-to-center type that is off in the center position and which gives three fast-tuning speeds to increase or decrease frequency.

Frequency Memory Unit

The Frequency Memory Unit is used primarily to provide automatic bandwidth lock-out capability for the receiver system. It may be programed to lock-out up to 20 MHz segments of the spectrum which are of no interest, whether signals are present or not. This equipment has a word-organized memory with storage for 18 frequencies to .1 MHz resolution. Although used to control the receiver system its operation is subordinate to the Digital Tuning Unit (through which it has its only physical and functional interface). The memory has four mutually exclusive modes of operation. Three of these modes enable the operator to alter or sample the contents of the memory. The fourth mode, sweep, performs the bandwidth lock-out function.

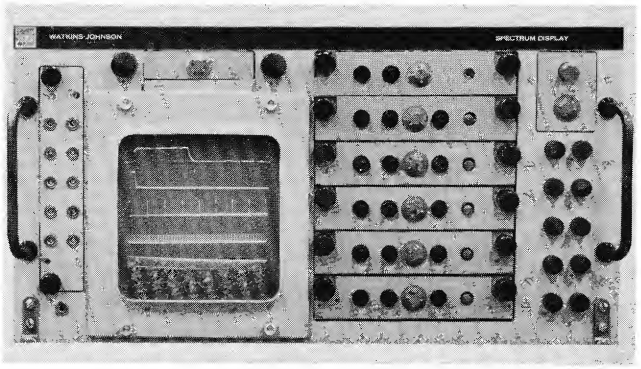


The bandwidth lock-out function enables the operator to quickly scan for new signals without having to personally discern between new and old signals, and to prevent his having to continually restart the sweep every time an old signal is encountered. It performs this function by overriding signal intercepts whose frequencies lie within the bandwidth limits stored within the 18 memory cells. When an intercept occurs, the memory is interrogated, and a comparison made between the frequencies in storage and the present intercept frequency of the sweep counter. If a coincidence occurs, a resume sweep gate is generated that automatically causes the receiver to continue its sweeping. On demand, the operator may select any frequency memory location and load the contents into the sweep counter. This automatically sets up the receiver to the desired frequency.

SIGNAL ANALYSIS

Spectrum Display Unit

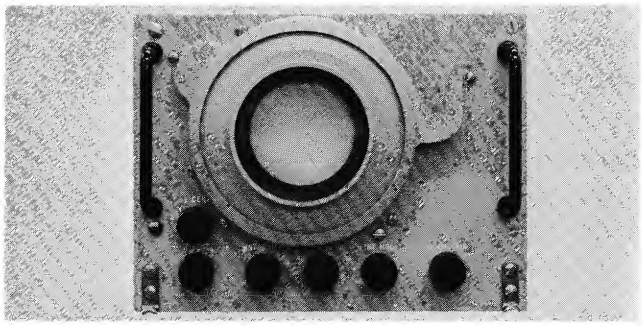
The Spectrum Display Unit provides the operator with a panoramic presentation of received signals as the system sweeps the microwave spectrum. The Unit uses a special five-trace cathode-ray-tube with provisions for trace photography through the rear of the tube. Each trace of the tube represents one of the five microwave bands and is correspondingly calibrated on one layer of a double-layer CRT graticule. Video information, fed to each electron gun of the CRT, is selectable in bandwidth. Analog tuning voltages are brought into the horizontal amplifiers for horizontal deflection, and an intensity marker is provided for each trace.



For the purpose of viewing repetitive pulsed signals wherein the time parameters may be of interest, the presentation can be switched to a conventional time display. This can be accomplished at any discrete point of the spectrum by energizing a strobe lock-on circuit. Trace presentation and calibration is automatically switched to enable visual examination of pulse duration and pulse repetition frequency (second layer of double-layer CRT graticule is automatically illuminated — first layer illumination is extinguished). Although several emitters within the receiver bandwidth may be detected, only one pulse train from an incoming multiple pulse train will be displayed. The time display feature of the Spectrum Display Unit assists the operator in setting up the pulse gate for proper functioning, and provides supporting data of information displayed in digital form by the Analysis Indicator Unit.

DF Display Unit

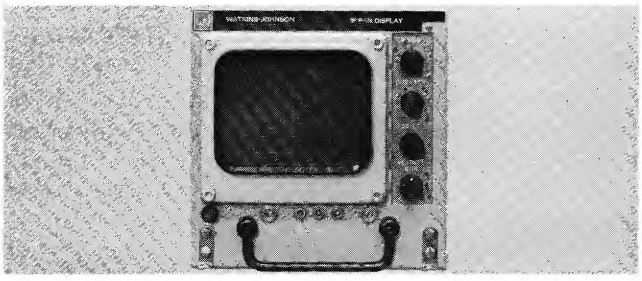
The DF Display Unit is used to permit the operator to make true bearings on intercepted signals. This bearing is automatically entered in the Analysis Indicator Unit for transmission and readout. This unit is a 1P-36/APA-69 Indicator with several modifications.



Modifications include increased overall dimensions of the unit; installation of a gear box and shaft angle encoder to give a BCD output of the true bearing; and inclusion of video switching relays. Although the relays are not integral to the operation of the display unit, they are placed inside the unit as a matter of convenience. The video amplifier, pulse stretcher and power supply for the DF Display Unit are provided from a modified GFE AM-256/APA-69. It should be noted that the DF Display Unit used with the current system is only usable with high-speed rotating antennae. If a tracking type antenna were used, a digtal readout would be desirable.

IF Pan Display Unit

The IF Pan Display Unit provides a single-trace 8 x 10 cm panoramic display of the receiver IF bandwidth. The bandwidth displayed is controlled by the Receiver Control Unit (1, 5 and 20 MHz). Signals within the IF passband may be examined whenever the sweep has stopped or is being manually tuned.



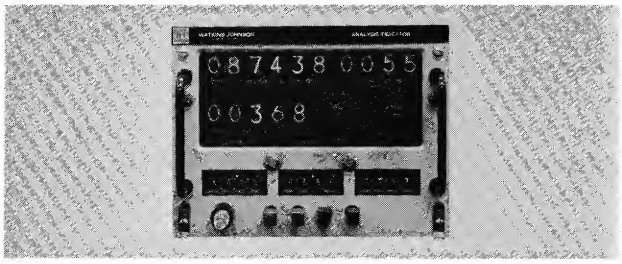
SIGNAL RECORDING

Analysis Indicator Unit

The Analysis Indicator Unit provides the operator with digital information pertaining to the frequency, pulse duration, and pulse repetition period of incoming signals which have been intercepted by the receiver system. All information is displayed in digital form on nixie-type tubes. Frequency is displayed to six digits, down to 100 kc/s increments; pulse duration is displayed to four digits, down to 0.1 μsec; and pulse repetition period to five digits, down to 1.0 μsec periods. All displayed information may be temporarily stored for subsequent data transmission.

The Analysis Indicator Unit is used whenever the receiver is not sweeping. Once the receiver intercepts a signal, the operator may automatically store information of frequency, pulse duration, pulse repetition period, time and true bearing of signal. After this data is stored, the operator may at his convenience enter latitude, longitude, aircraft number, operator number, and type of signal on 12 thumbwheel switches located on the front panel of the unit.

After all pertinent information is entered and stored, the data may be simultaneously transmitted and printed out locally. Circuits are included for converting this data to teletype format. If the transmitter is not available, the data will remain stored until such time as it may be transmitted, and sweeping may be continued. The first block of data will remain stored even while the receiver is searching for additional signals.



If a second signal is encountered, the first data block must be transmitted or printed out locally. This must be accomplished prior to storing the second information block (storage automatically erases previously-entered data). If required, any number of data blocks may be recorded locally in this manner and then manually retransmitted by teletype at a later time. The data format for local printout and transmission is shown below:

DATA	DIGITS
Aircraft Number	00
Operator Number	0
Frequency (MHz)	00000.0
Type of Signal	0
Pulse Duration (μsec)	000.0
Pulse Repetition Period (μsec)	00000
Time (hours, minutes & seconds)	00 00 00
Latitude (degrees & minutes)	00 00
Longitude (degrees & minutes)	00 00
True Bearing (degrees)	0 00

Additional information on the WJ-1007 may be obtained through our representative in your area, or by contacting Watkins-Johnson Company, 3333 Hillview Avenue, Palo Alto, California. Inquiries to our Palo Alto facility should be addressed to the attention of Applications Engineering.

Tentative Specification

WJ-1007

MICROWAVE COLLECTION SYSTEM

This specification covers a microwave electromagnetic surveillance receiver system in the 1 to 18 GHz range. The system includes provisions to receive, detect, analyze and display currently used types of electromagnetic emission.

1-1. GENERAL SYSTEM CHARACTERISTICS

This receiver system is a complete, operating state-of-the art system employing the latest techniques to achieve the specifications stated in this document.

1-1-1. Weight & Size. Weight and physical dimensions are kept to a minimum in keeping with proper design standards for aircraft and proper receiver system operation and maintenance. The weight of the complete system, less antennas and drive units, is 850 pounds.

1-1-2. Solid-State Circuitry. Solid-state circuitry is employed where practical and where such use results in more dependable operation, savings in weight, size and power consumption.

1-1-3. Frequency Coverage Expandability. The receiver system is designed so as to be expandable to cover the 20 to 40 GHz range and, without major design changes, to cover the range from approximately 200 to 1000 MHz.

1-1-4. System Compatibility. The receiver system is compatible for use in aircraft, ships, mobile vans and fixed stations.

1-1-5. System Completeness. All equipment and parts required for proper operation of the receiver system are provided, except as specified in paragraph 1-1-6 of this specification. The following units are supplied for all applications:

1-1-5-1. Five RF Tuning Units covering the 1 to 18 GHz range.
1-1-5-2. One Demodulator Unit.
1-1-5-3. One Digital Tuning Unit.
1-1-5-4. One Receiver Control Unit.
1-1-5-5. One Frequency Memory Unit.
1-1-5-6. One Spectrum Display Unit.
1-1-5-7. One Analysis Indicator Unit.
1-1-5-8. One IF Pan Display Unit.
1-1-5-9. One Local Oscillator Unit.
1-1-5-10. One Local Oscillator Driver Unit.
1-1-5-11. One Bench/Panel Box with speaker.
1-1-5-12. One Set Interconnecting Cables.

The following units would be applicable to airborne operation only. Suitable alternative equipment would be required for other applications.

1-1-5-13. Directional Antenna, 8 to 18 GHz.
1-1-5-14. Omni-Directional Antenna, 8 to 18 GHz.
1-1-5-15. Diplexer, 1 to 4 GHz.
1-1-5-16. Diplexer, 8 to 18 GHz.
1-1-5-17. Modifications to optional equipment (see paragraph 1-1-6 below).

1-1-6. Optional Equipment. Normally, the following equipment is not furnished by Watkins-Johnson Company due to variations in customer requirements. However, these or equivalent units can be furnished on an optional basis.

1-1-6-1. One AN/APA-69 Direction Finding System consisting of two antennas, three TG-8A/APA-69 Antenna Drive Units, one IP-36/APA-69 Indicator Unit, and one AM-256/APA-69 Video Amplifier/Power Supply for the IP-36/APA-69 Indicator Unit.

1-1-6-2. One AN/TRC-75 High-Frequency, Single-Sideband Transceiver.

1-1-6-3. One AN/TGC-14V Teletype Unit.

1-1-7. Overall Receiver Performance.

1-1-7-1. SYSTEM NOISE FIGURE (at RF Tuning Unit inputs):

Frequency (GHz)	Noise Figure (dB)
1–2	8
2–4	8.5
4–8	10
8–12	13
12–18	15.5

1-1-7-2. DYNAMIC RANGE. The dynamic range of the receiver system with AGC is at least 60 dB without the use of manual attenuators. The linear dynamic range (no AGC or attenuators) is at least 20 dB.

1-1-7-3. WARMUP & STABILIZATION TIME. The receiver system is ready for use in the time it takes the traveling-wave-tubes to come on (normally 7 to 10 minutes). It will operate with stated accuracy in 15 minutes.

1-1-7-4. READOUT DELAY TIME. Upon signal intercept, frequency readout is immediate. Parameter digitization time depends on actual signal pulse width and pulse repetition period.

1-1-7-5. RECEIVER CONTROL. All input tuning commands and output intercept data are in binary-coded-decimal format facilitating fully-automated or computer-controlled operation.

2-1. DESIGN CHARACTERISTICS

2-1-1. 1 to 8 GHz Antennas. The 1 to 8 GHz frequency range is covered by two antennas of the APA-69 type. One antenna is for 1 to 4 GHz and the other for 4 to 8 GHz. A single log periodic antenna,

covering the entire 1 to 8 GHz range, can be used in lieu of the two APA-69 antennas if desired (additional multiplexing is required).

2-1-2. 8 to 18 GHz Antennas. Two antennas are used for the 8 to 18 GHz range. Both cover the entire range, but one is directional and the other omni-directional.

2-1-2-1. 8 TO 18 GHz DIRECTIONAL ANTENNA. This 45° offset antenna reflector mounts on a TG-8A/APA-69 rotational drive unit. A fixed circular-polarized horn is used as a feed, thus eliminating the necessity for a rotary joint.

2-1-2-1-1. Beam Width at 3 dB Points. Vertical plane — approximately 30 degrees. Horizontal plane — approximately 20 degrees. The vertical beam is capable of being tilted in fixed positions of +15 and —5 degrees, referenced to the plane of the base plate. The tilted fixed positions are manually set at the time the antenna is installed in the vehicle.

2-1-2-1-2. Antenna Gain. The antenna gain is 16 dB or greater.

2-1-2-1-3. Mounting Area. The antenna is placed on a rotating base plate, 15 inches in diameter with maximum height of 11.5 inches with the upper corner rounded at approximately a 6-inch radius.

2-1-2-1-4. Antenna Rotation and Stability. The base plate rotates from 20 to 360 r/min. The antenna has complete dynamic stability throughout this range.

2-1-2-1-5. Polarization. The antenna is capable of receiving vertically and horizontally polarized signals equally well.

2-1-2-1-6. Antenna Drive Units. The TG-8A/APA-69 Antenna Drive Units are modified by Watkins-Johnson Company to provide a manual slewing position.

2-1-2-1-7. Antenna Switching. Antenna switching is accomplished automatically through diplexers and in such a manner to preclude any sizable lapse of operation.

2-1-2-2. 8 TO 18 GHz OMNI-DIRECTIONAL ANTENNA. This is a circular polarized omni-directional antenna designed for aircraft use. It is housed in a small Rexan radome. The antenna has ½ dB gain over an Isotropic, VSWR of less than 3:1, and an azimuth pattern omni-directional within 1.5 dB. An OSM type connector is used.

2-1-3. RF Characteristics. Five RF Tuning Units cover a frequency range from 1 to 18 GHz. The tuning units scan this range sequentially. RF Tuning Units cover the following ranges: 1–2 GHz, 2–4 GHz, 4–8 GHz, 8–12 GHz and 12–18 GHz.

2-1-3-1. RF/IF ATTENUATION. Calibrated attenuation is provided and is controlled manually from a Receiver Control Unit. The attenuator control is calibrated from 0 to 84 dB in 6 dB increments with an insertion loss of 0.5 dB or less at the 0 dB position. An indicator is provided on the Receiver Control Unit to indicate when the attenuator is in any position other than zero.

2-1-3-2. TUNING OVERLAP. The RF Tuning Units have an overlap equivalent to one IF bandpass unit.

2-1-3-3. RF PRESELECTION. Electronically tuned preselectors are employed on all bands. The bandwidth of the RF stages is sufficiently wide to allow overall receiver bandwidth to be effectively that of the IF stages. Image frequency rejection is better than 80 dB, and spurious rejection better than 60 db — both figures at the highest operating frequency.

2-1-3-4. RF PREAMPLIFICATION. At least 20 dB of gain is provided on all bands by the RF Tuning Units. The RF Tuning Units are packaged in enclosures of standard ATR type.

2-1-4. IF Characteristics.

2-1-4-1. IF BANDWIDTH. The IF bandwidth is variable; with manual control for selection of 1, 5 and 20 MHz bandpass measured at 3 dB points.

2-1-4-2. IF TOLERANCE. The IF bandwidths are maintained within ±5% of the bandwidth stated in paragraph 2-1-4-1 (above).

2-1-4-3. IF RIPPLE. The IF Pan ripple does not exceed 1.5 dB from the mean gain.

2-1-5. Local Oscillator. The frequency accuracy of the first and second local oscillators is derived from a Hewlett-Packard frequency synthesizer specially modified by Watkins-Johnson Company. This unit has a short-term stability of 3×10^{-11} ppm, and provides the 100 MHz drive for YIG-tuned harmonic generators in the RF Tuning Units plus 260 to 360 MHz drive to the second mixer in 100 kc/s steps by digital control.

2-1-6. Beat Frequency Oscillator. An audio tone is provided for monitoring continuous-wave type signals.

2-1-7. Detection. AM and FM detector circuits are provided that are manually selectable from the Receiver Control Unit.

2-1-8. Video Amplification Response. The frequency response of the video amplifier is 10 MHz.

2-1-9. Pulse Gate.

2-1-9-1. SELECTIVE GATING. A gating circuit is provided to discriminate among pulse signals of different PRF's which lie within the receiver bandwidth. The operator is able to select any one of these signals which he desires to monitor while rejecting the other signals. This feature is operative only when the sweep is stopped. The outputs of the gating circuit are fed to the Analysis Indicator and DF Units simultaneously.

2-1-9-2. BYPASS. Bypass circuitry is provided to eliminate selective gating from the receiver system.

2-1-10. Audio Output. Provisions are made for an audio output after the pulse gate.

2-1-10-1. SPEAKER. A small speaker is provided to monitor the audio output (Bench/Panel Box).

2-1-10-2. PHONE JACK RECEPTACLE. A phone jack receptacle is provided to match a standard 300-ohm headset.

2-1-10-3. AUDIO LEVEL CONTROL. The audio level to the speaker and phone jack is regulated by means of a volume control. The speaker is provided with an on-off switch which does not affect the level to the phone jack.

2-1-11. Analysis Indication. An Analysis Indicator Unit is provided to present a visual display of pulse width, pulse repetition period, and frequency.

2-1-11-1. PULSE WIDTH. The pulse width readout has a capability of displaying pulses ranging from 0.1 to 999.9 μsecs in width. Readout accuracy is within 0.1 μsec.

2-1-11-2. PULSE REPETITION PERIOD. The pulse repetition period readout has a capability of displaying periods ranging from 1 to 99999 μsecs. The accuracy of the pulse repetition period readout is maintained within 1.0 μsec.

2-1-11-3. FREQUENCY. The frequency readout is automatic with precision and resettability of 100 kc/s in the 1 to 18 GHz range and accuracy of 3 parts in 10^9. When the receiver is locked-on a signal, the operator can manually center the signal on the IF Pan Display to meet the frequency precision stated herein.

2-1-12. Direction Finding Presentation. The DF presentation is supplied by a modified IP-36/APA-69. Presentation is of the polar type of amplitude versus bearing. Modifications to the DF Display Unit are made by Watkins-Johnson Co.

2-1-12-1. CURSOR. A manually-controlled cursor is provided to indicate the direction of the signal being analyzed. The cursor position is automatically converted to a digital format indicating true bearing to within one degree, and is stored in the Analysis Indicator Unit.

2-1-13. Spectrum Display. A Spectrum Display Unit is provided for displaying a visual plot signal amplitude versus frequency for the entire frequency spectrum. The display employs a separate trace for each tuning range.

2-1-13-1. SCOPE EXPAND. When the tuning scan is narrowed, the display may be expanded to cover the entire graduated scale (with the aid of horizontal gain and position controls).

2-1-13-2. CALIBRATION. Graduated frequency scales are provided on the graticule for visual determination of frequency in normal, full sweep operation. Scales are accurately calibrated to allow correct frequency reading to within 5%.

2-1-13-3. LOGGING SCALE. A graduated, linear logging scale is provided for use on each trace of the expanded presentation.

2-1-13-4. STROBE MARKER. A manually-controlled strobe marker of the intensity modulation type is provided for each trace. When a momentary contact switch is activated, the tuner locks on the strobe marker frequency and digital readout of the frequency occurs (on the Analysis Indicator Unit).

2-1-13-5. PULSE WIDTH DISPLAY ACCURACY. Pulse width can be measured within ± 0.1 μsec accuracy for pulses from 0.1 to 5 μsecs in width and within ± 1.0 μsec accuracy for pulses from 5 to 50 μsecs, and ± 10 μsecs for pulses from 50 to 500 μsecs.

2-1-13-6. PULSE REPETITION FREQUENCY DISPLAY ACCURACY. Pulse repetition frequency can be measured from 20 to 20,000 pulses per second with an accuracy of 10%.

2-1-14. IF Pan Display. The IF Pan Display Unit presents, on a linear 8 x 10 cm graduated scale, frequency activities within the receiver bandwidth when the signal is locked-on or when the receiver is being manually tuned.

2-1-15. Tuning Control. Frequency scanning is accomplished electronically.

2-1-15-1. MANUAL TUNING. Provision is included for manual tuning. This includes a 3-speed fast tune lever (in both directions) plus a standard type tuning knob.

2-1-15-2. SCAN RATE. Automatic frequency scanning from 1 to 18 GHz is continuously variable at a rate of 0.3 GHz to 300 GHz per second. A scanning rate of 20 sweeps/second for an individual tuning unit is provided.

2-1-15-3. SECTOR SCANNING. Provisions are included for continuously narrowing the scanning limits from coverage of the entire spectrum down to 20 MHz; below which the IF Pan Display Unit is used to provide further resolution. The time interval between sectors being scanned does not exceed 1 millisecond.

2-1-15-4. SETTING OF SECTOR SCANNING LIMITS. Upper and lower sector limits are independently set by means of thumbwheel switches on the Digital Tuning Unit.

2-1-15-5. TUNING UNIT SELECTION. Provisions are made for scanning one, any combination, or all tuning units.

2-1-15-6. SWEEP SYSTEM. The sweep system automatically stops on any signal within a sector that is above a manually preset threshold level, except when the signal is previously recorded on a Memory Unit. Scanning resumes at the control of the operator.

2-1-16. Memory Capability. A memory system is included with capabilities for storage of frequency and bandwidth necessary for identification of sixteen signals. Once a signal is in storage, by operating a recall control, the receiver will tune directly to that frequency. A switch is provided to clear any memory channel to allow setting up a new frequency.

2-1-16-1. LOCK-OUT CAPABILITY. The sweep does not lock on a signal that has been recorded in the memory unit, except for a 120 μsec period required to identify that the signal has been recorded in the memory. Adjustable manual controls are provided to establish the upper and lower limits of the band of frequencies that represent the signal that is locked-out. The adjustments are from +0.1 MHz to +19.9 MHz of the low-frequency end of the band. The increments of adjustment are 0.1 MHz. The IF Pan Display indicates the position of the limits relative to the signal as they are being adjusted for memory.

2-1-16-2. RECALL CAPABILITY. The minimum capability of accuracy for recalling low-end frequencies is 0.1 MHz.

2-1-17. Data Transmission. A short-term storage device is provided in the Analysis Indicator Unit for storage of digital readout information of one signal to be transmitted by TTY. This device records information only when the receiver is locked-on a signal and automatically clears whenever sweep is resumed. An override switch is provided to store information indefinitely, even though the sweep is resumed. No new information can be admitted under this condition. However, the operator may press a switch and the stored information is sent in sequence to the TTY conversion circuitry (located in the Analysis Indicator Unit). A storage register automatically stores the pulse width, pulse repetition period, true bearing and frequency, with additional inputs for aircraft number, latitude and longitude, operator number, and time and two spare memory inputs. The aircraft position and time are in digital form.

2-1-17-1. TELETYPE CONVERSION. Appropriate circuitry is included in the Analysis Indicator Unit to provide changing digital information into TTY format. This system is compatible with AN/TRC-75, high-frequency, single-sideband equipment and the AN/TGC-14V teletype equipment. This equipment utilizes standard 7.42 teletype format for 60 or 100 wpm, and operates on a standard keyed on-off 60 mA dc circuit.

2-1-18. Power. Power supplies for all units are self-contained and operate from 110 to 125 volts ac, 50 to 420 c/s, 1 or 3-phase primary power source. Adequate overload protection is provided.

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